CONCRETE PAVEMENT TECHNOLOGY PROGRAM

PROJECT SUMMARIES

U.S. Department of Transportation
Federal Highway Administration

CONCRETE PAVEMENT TECHNOLOGY PROGRAM – PROJECT SUMMARIES

Today, heavier loads, increased traffic, and higher speeds are placing greater demands on America's overcrowded highways, roads, and streets. Improvements to current concrete pavement technology are needed. To this end, the Transportation Equity Act for the 21st Century (TEA-21) provided $30 million—$5 million per year—to "carry out research on improved methods of using concrete pavement in the construction, reconstruction, and repair of Federal-aid highways."

To carry out the research specified in TEA-21, the Federal Highway Administration (FHWA), in partnership with the States, industry, and academia, developed an ambitious program to carry out the TEA-21 mandate. The Concrete Pavement Technology Program (CPTP) consists of research, development, and technology delivery activities to improve the performance and cost-effectiveness of concrete pavements.

CPTP has four goals:

- Reduce user delays.
- Reduce costs.
- Improve performance.
- Foster innovation.

These goals address the needs of the State departments of transportation (DOT), the concrete pavement industry, and the highway user while supporting FHWA's strategic goals of improving the mobility, productivity, and safety of the Nation's highway system. In June 2002, the cooperative agreement between FHWA and the Innovative Pavement Research Foundation (IPRF) was terminated; however, FHWA remains committed to continuing the vital research needed to reach the goals of CPTP.

CPTP will produce practical and readily useable tools, guidelines, procedures, methods, and software to be used in the material selection, mix design, pavement design, construction, and operation of concrete pavements.

More than 30 projects identified in CPTP are in progress. The attached project summary sheets highlight the goals and progress for each project.

This status report was prepared for the March 17–18, 2003, meeting of the Transportation Research Board (TRB) Committee for Research on Improved Concrete Pavements.

TASK/STUDY NUMBER	TITLE
Task 1(99)	**Traffic Management Optimization Pilot Studies for Reconstructing Urban Freeways**
Task 1(99)	**Impact of Texturing and Surface Treatment on Reducing Wet-Weather Accidents**

TITLE: Traffic Management Optimization Pilot Studies for Reconstructing Urban Freeways

TASK/STUDY NUMBER: Task 1(99)

OBJECTIVE: Demonstrate construction processes and traffic management strategies aimed at minimizing traffic and user disruption.

BACKGROUND: Often the temporary disruption caused by the reconstruction of pavements results in costs to the highway user and the local community that dwarf the capital cost of renewal. Concrete pavement contractors suggest that there are a variety of innovative construction methods and traffic management methods available to reconstruct a meaningful section of urban freeway with long-life pavement. Unfortunately, there is general skepticism among some engineers that long-life pavement reconstruction can be accomplished with minimal user disruption. Success in providing a quality long-life pavement with minimal user disruption would significantly improve safety and substantially reduce user costs because these routes would be open to serve traffic. Worker safety may also be improved by reducing workers' exposure to traffic during construction.

SCOPE OF WORK:
- Surveys of motorists and residents.
- Pilot project(s) on urban highways to demonstrate traffic management optimization principles.
- Documentation of planning and construction processes and logistics for pilot projects.
- Conceptual studies to determine and document traffic management options for reconstruction projects in the planning phase. Key deliverables are development and refinement of the matrix tool, which is intended to guide decisions on public involvement approaches.
- Technology-transfer information, including a national open house for a pilot project. Technology-transfer products may include, but are not limited to, reports, summary papers, brochures, posters, audio/visual presentations, slide shows, videos, CD-ROMs, DVDs, and/or a World Wide Web site.
- Not included in this project: Develop scope, cost, and schedule for technology transfer (see task 65).

PERIOD OF PERFORMANCE: April 1, 2003–March 31, 2005

COST: $421,830 (includes 20 percent matching funds)

CONTRACTOR/PRINCIPAL INVESTIGATOR: Texas Transportation Institute/Stuart Anderson

STATUS: A contract, including a revised and updated statement of work, was awarded to the Texas Transportation Institute, with a 2-year period of performance as shown above.

TITLE: Impact of Texturing and Surface Treatment on Reducing Wet-Weather Accidents

TASK/STUDY NUMBER: Task 2(99)

OBJECTIVE: This project will review accident data from pavements with varying surface treatments. The data will be analyzed to determine a relationship between surface type, noise, surface texture, and wet-weather accidents. Guidelines will be developed for optimal surface textures.

BACKGROUND: The different methods of creating the macrotexture portion of pavement surface textures have not been correlated with a reduction in wet-weather accidents. A study to analyze the correlation will determine the different impacts of each type of surface texturing method on wet-weather accidents. The study will primarily focus on the macrotexture component of surface texture for concrete pavements related to wet-weather accidents.

STATUS: Canceled on January 23, 2002.

TITLE: Performance and Design of Whitetopping Overlays for Heavily Trafficked Pavements

TASK/STUDY NUMBER: Task 3(99)

OBJECTIVE: The research effort for task 3(99) has four major objectives:

- Document, based in part on available data, the performance of the three classes of whitetopping overlays: ultra-thin (less than 102 millimeters [mm] [4 inches]), thin (102 to 203 mm [4 to 8 inches]), and conventional (greater than 203 mm [8 inches]).
- Develop a design procedure for each class that takes critical parameters and site conditions into account.
- Develop best practices construction and quality control guidelines to ensure that quality whitetopping pavements are built.
- Identify potential rehabilitation alternatives and solutions.

BACKGROUND: Whitetopping has been used extensively throughout the United States. The design of these overlays has been based on conventional procedures, which assumes that the existing asphalt pavement is a stabilized base course. In many instances, all three classes of whitetopping have exceeded their design expectations. Research is needed to determine an appropriate mechanistic design procedure. In addition to the design procedure, research is needed to identify the existing pavement conditions that influence whitetopping performance for each class of overlay.

SCOPE OF WORK:

- Document the performance of three broad classes of whitetopping overlays based on available data (and additional data collected on about five projects).
- Develop a mechanistic whitetopping design procedure for each class of overlay that takes into account the critical parameters and site conditions.
- Develop best practices construction and quality control guidelines that address the issues needed to ensure that a quality pavement is built.
- Identify potential rehabilitation alternatives for each class of whitetopping. Specific items to be included in each class are best practices, sensitivity to conditions and design parameters, quality control, and possible problems and probable solutions.

START DATE: February 2000

DURATION: 18 months (extended to 29 months through July 2002)

COST: $359,900

CONTRACTOR/PRINCIPAL INVESTIGATOR: The Transtec Group, Inc./Robert Otto Rasmussen, Ph.D.

STATUS: At the panel meeting in May 2002, the latest version of the software and the construction and rehabilitation guidelines were presented and distributed on a CD-ROM. The contractor has invoiced IPRF for the full contract amount. IPRF informed FHWA that the final products would be completed and delivered to FHWA at a future date. No delivery date has been established.

TITLE: Tests or Standards to Identify Compatible Combinations of Individually Acceptable Concrete Materials

TASK/STUDY NUMBER: Task 4(99)

OBJECTIVE: The objectives and expected results of this research are to develop practical test procedures and criteria to assess the effects of combinations of materials for concrete pavements on:

- Early stiffening and excessive retardation that can affect workability, placeability, consolidation, and finishing.
- Potential for early-age cracking, including plastic shrinkage, and possibly the ability to attribute the cause of cracking to chemical, physical, and environmental phenomena.
- Characteristics of the air-void system, including nonuniformity; insufficient air; coalescence of air voids around aggregate; and excessively large air voids, all of which influence strength or durability, or both.

BACKGROUND: Frequently, field experience has indicated that certain material combinations may result in undesirable effects on concrete properties, such as early stiffening (false set or flash set), inadequate or excessive retardation, excessive cohesiveness, problems with air entrainment, loss of workability, lower than expected strength, and unexpected cracking at early ages.

Reliable tests are needed to predict the potential incompatibility of concrete materials that adversely influence the fresh and hardened properties of concrete at early ages. For example, combinations of incompatible materials may lead to early stiffening and unworkable concrete. American Society for Testing and Materials (ASTM) C359 was developed to evaluate early stiffening of portland cement and may not be applicable for evaluating combinations of cementitious materials and the interaction with chemical admixtures. A recent approach that may be more applicable to a combination of materials is the minislump cone test. No test exists to predict the potential for plastic cracking or early-age hardened concrete cracking caused by chemical, physical, or environmental phenomena. There is also no test to evaluate the potential for coalescence of air voids around aggregates; an unstable air-void system under placement and consolidation; or a process that identifies an air-void system in fresh concrete that will be detrimental to strength or durability, or both.

This research effort should produce tests and procedures to enable material suppliers, concrete producers, and users to identify undesirable material combinations that adversely affect the early-age properties of concrete, evaluate the uniformity of individual materials from the same source, and optimize the combinations for predictable early-age performance. Cracking and durability-related distress in the long term (later ages) are not included in the scope of this project.

SCOPE OF WORK: In phase I, the researchers performed a comprehensive literature review and developed a work plan for phase II to develop simple test methods for evaluating the compatibility of combinations of concrete component materials in paving concrete mixtures relative to the three focus areas listed in the objective. The effects of other factors, such as production and placement methods, factors that influence finishability, and the influence of environmental conditions such as temperature and humidity, will be evaluated. Deficiencies in existing test methods for assessing the suitability of materials for making concrete will be identified. The procedures that are developed will be incorporated into guidelines to evaluate and qualify combinations of materials for use in concrete pavements. The researchers will propose methods for disseminating the information (technology transfer) to producers, contractors, and users.

START DATE: Project restarted in March 2003.

TITLE: Accelerated Load Tests of Ultrathin Whitetopping

TASK/STUDY NUMBER: Task 5(99)

OBJECTIVE: Verify and/or calibrate existing ultrathin whitetopping (UTW) design procedures using testing data from the ultrathin overlay projects at FHWA's Accelerated Loading Facility (ALF) at the Turner-Fairbank Highway Research Center (TFHRC).

BACKGROUND: UTW overlays are relatively new composite pavement designs using 51- to 102-mm- (2- to 4-inch-) thick concrete overlays of asphalt pavements. The original ultrathin overlay concept, developed in 1990, was for light-traffic situations. In practice, some ultrathin projects have been constructed on heavy-truck ramps and even on high-speed highways. Early performance of these pavements has been excellent, exceeding most expectations. Full-scale load tests were conducted from May 1998 to December 2000 at FHWA's TFHRC under a cooperative agreement between FHWA and the American Concrete Pavement Association (ACPA). Analyses of these test results isolated performance intricacies, revised existing design procedures, and calibrated models.

SCOPE OF WORK:
- Conduct complementary tests at FHWA's ALF, including bond pull-off, spectral analysis, falling-weight deflectometer, and mechanical strain gauges joint and crack openings.
- Use data from tests to verify/calibrate existing UTW design procedures.
- Conduct technology-transfer workshop.
- Produce and distribute technology-transfer documents.

PERIOD OF PERFORMANCE: 1999–2001 (revised to 2003)

COST:

Testing at FHWA's TFHRC facility and analysis of the data:	$200,000
Technology-transfer workshop:	35,000
Other technology transfer:	48,000
Total allocation for task:	$283,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: The Transtec Group, Inc./Robert Otto Rasmussen, Ph.D.

STATUS: Load testing and supplementary data collection were completed. The data from the ALF tests were analyzed as part of task 3. A technology-transfer workshop was conducted in October 1999. The IPRF contractor, The Transtec Group, Inc., made several site visits to FHWA's ALF to collect joint opening and bond data. The contractor included these results in the task 3 interim report. The deliverables from this task will include an executive summary, an ALF UTW database, and recommendations and concepts for technology-transfer materials. It is also anticipated that these materials will include a set of summary brochures and sheets, plus electronic presentations of the final results.

TITLE: Incremental Costs and Performance Benefits of Various Features of Concrete Pavements

TASK/STUDY NUMBER: Task 6(99)

OBJECTIVE: Determine the most cost-effective combination of design features for concrete pavements, considering the estimated costs and expected performance improvements of each feature.

BACKGROUND: There are a variety of design choices or features available for concrete pavements. A standard design using certain features is often propagated by a State agency for use systemwide. In many cases, these standard designs remain constant over many years. Eventually, there may become little institutional knowledge of the purpose and interrelationship of the standard sections' features, particularly regarding expected cost and performance. To apply the most cost-effective combination of features and requirements, it is necessary to know how each impact the initial construction cost and pavement performance. While there have been several featured performance studies in the past, including those for long-term pavement performance, the cost aspects have been largely ignored. Until the costs and benefits of the design and requirement features are examined together, the issue of performance optimization will remain unclear. This project will address this gap in knowledge.

SCOPE OF WORK:
- Conduct a limited review of related work.
- Prepare and submit data collection plan for approval.
- Survey construction cost estimators for relative construction costs for the range of features.
- Tabulate the relative cost of various pavement components on a State, regional, and nationwide basis.
- Survey, tabulate, and summarize the performance expectations (based on expert opinion) of highway pavement design personnel for each feature. Compare these results with results done by others (e.g., the Long-Term Pavement Performance [LTPP] program studies).
- Prepare and submit interim report.
- Develop computer software capable of evaluating the impact of design features based on user input.
- Present project findings and draft final products to task panel.
- Prepare and submit final products.

PERIOD OF PERFORMANCE: August 2000–June 2003

COST: $174,432

CONTRACTOR/PRINCIPAL INVESTIGATOR: Applied Pavement Technology/Kurt Smith

STATUS: The project began in August 2000 with a review of previous work and the development of the data collection plan. A limited literature review was completed in January 2001, and the results were made available to interested parties in Adobe® portable document format (PDF) electronic files. In February 2001, the researcher completed the data collection plan, including detailed cost and performance estimation forms. Data collection was initiated in March 2001. Of the 35 contractors who volunteered to provide relative cost estimates, 18 actually did so by responding to the questionnaire that was sent to them. Of the 23 agency engineers who volunteered to provide performance estimates, 15 actually did so by responding to the questionnaire. An interim report was completed in March 2002. Software capable of evaluating the impact of design features is being finalized. A draft final report will be submitted in March 2003, and a final meeting of the advisory panel will be held shortly thereafter.

Percentage of work completed: 72 percent (as of February 26, 2003).
Percentage of total funds spent: 69 percent (as of February 26, 2003).

TITLE: Field Trials of Concrete Pavement Product and Process Technology

TASK/STUDY NUMBER: Task 7(99)

OBJECTIVE: Conduct field trials for new products, processes, and technologies in actual construction projects.

BACKGROUND: In many cases, implementing new technology in the highway industry presents a major challenge. A contractor cannot use technology unless it is specified; however, a State cannot specify or allow a new technology until it is tried and proven. Task 7 seeks to encourage State agencies to partner with their local contractor and material/equipment suppliers to implement new or improved existing technology. Through open solicitation, public and private agencies can seek funding to try new or improved concrete pavement technologies under field conditions. Reports, photographs, and videos will capture each effort for education and technology-transfer purposes.

SCOPE OF WORK:
- Select candidate projects based on set criteria.
- Monitor projects for a minimum of 3 years.
- Write reports: construction report, yearly evaluation reports, and a final report.
- Develop publications that present recommendations and findings.

PERIOD OF PERFORMANCE:
March 27, 2000–December 31, 2000, Construction Technology Laboratories, Inc. (9 months)
June 26, 2000–June 26, 2003, University of Washington
May 1, 2001 October 2003, Construction Technology Laboratories, Inc.

COST:
- $96,000, Project Management contract (Peak Management Associates)
- $55,000, UTW Repair Techniques research contract
- $60,000, Weekend Intersection Reconstruction
- $99,000, Instrumentation of UTW in Colorado
- $99,321, Precast Concrete Slabs for Full-Depth Repairs
- $85,141, Implementation of Total Environmental Management for Pavements (TEMP) System
- $100,000, Magnetic Tomography to Evaluate Dowel Bar Placement
- $100,000, Field Evaluation of Elliptical Steel Dowel Performance
- $100,000, Evaluation of performance-related specifications (PRS) in Tennessee

CONTRACTOR/PRINCIPAL INVESTIGATOR:
- UTW Repair Techniques (Construction Technology Laboratories, Inc./Shiraz Tayabji)
- Weekend Intersection Reconstruction (University of Washington/Kamran Nemati)
- Instrumentation of UTW in Colorado (Construction Technology Laboratories, Inc./Chung Wu)
- Precast Concrete Slabs for Full-Depth Repairs (Michigan State University/Neeraj Buch)
- Implementation of TEMP System (The Transtec Group, Inc./Robert Otto Rasmussen, Ph.D.)
- Use of Magnetic Tomography to Evaluate Dowel Bar Placement (ERES Consultants, Inc./Lev Khazanovich)
- Field Evaluation of Elliptical Steel Dowel Performance (Iowa State University/Jim Cable)
- Evaluation of PRS in Tennessee (ERES Consultants, Inc./Nasir Gharaibeh)

STATUS:
- Project Management contract with Peak Management Associates was cancelled by IPRF.
- UTW Repair Techniques project has been completed; report and video are available.
- Weekend Intersection Reconstruction report/video are finished.
- Instrumentation of UTW in Colorado is approximately 70 percent completed; final report is expected in late 2003.
- Precast Concrete Slabs project was awarded to Michigan State University on March 4, 2003.
- Remaining contracts awarded in March–April 2003.

TITLE: Performance and Design of Separated (Unbonded) Concrete Overlays

TASK/STUDY NUMBER: Task 8(99)

OBJECTIVE:
- Document the performance history of separated (unbonded) overlays subjected to high truck volumes.
- Document the design parameters, site conditions, material properties, etc., that are related to long-term performance of separated (unbonded) overlays:
  1. Interlayer (role, characteristics, materials, thickness, quality control/quality assurance [QC/QA] testing).
  2. Overlay materials.
  3. Environmental factors.
- Develop field-validated, mechanistically based design models consistent with the proposed 2002 Pavement Design Guide for separated (unbonded) overlays that predict the overlay response to environmental and wheel loads, considering interlayer and overlay materials.

BACKGROUND: Unbonded concrete overlays of concrete pavements have been used since the early 1900s. These overlays contain a separation interlayer between the old and new concrete layers that debounds the two concrete layers and prevents the joints and cracks in the underlying concrete pavement from reflecting into the new concrete overlay. Currently, separated concrete overlays are designed without considering the effects of the interaction between the overlay and the underlying pavement.

In addition, recent research on UTW suggests that short joint spacing plays a major role in the performance of thin concrete overlays.

SCOPE OF WORK: This project will develop analytical models and mechanistically based design procedures that accurately predict the response of separated overlays to environmental and wheel loads. It is anticipated that two major issues will be researched:
- Does the interaction between the overlay and the old concrete add to the structure of the pavement system and, if so, by how much? How can it be accounted for?
- Does short joint spacing and bonding interaction affect unbonded overlays in a similar manner as UTW?

It is anticipated that this project will consist of analytical work, full-scale instrumentation, and load testing, as well as collection, documentation, and analysis of field performance data for improving overlay thickness design procedures.

START DATE: After public availability of the proposed 2002 Pavement Design Guide.

DURATION: 30 months

COST: $500,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: To be determined.

STATUS: This project was previously solicited by IPRF, but must be competitively bid according to Federal procurement regulations. As this project is dependent on the content of the proposed 2002 Pavement Design Guide, this project will be deferred until the proposed 2002 Pavement Design Guide is publicly available. The guide is anticipated to be publicly available in mid- to late-2003.

TITLE: Influence of Sealing Transverse Contraction Joints on the Performance of Concrete Pavement

TASK/STUDY NUMBER: Task 9(00)

OBJECTIVE: Examine the effect of sealing transverse contraction joints on long-term pavement performance using existing test sections.

BACKGROUND: Currently, 96 percent of the State highway agencies (SHA) require transverse joint sealing, adding about 2 to 7 percent to the initial construction cost of their pavements and even more when considering resealing activities and life-cycle cost analysis (LCCA). If the use of narrow, unsealed joints on short jointed concrete pavements can provide the same long-term pavement performance as sealed joints, States can save millions of dollars in construction and maintenance costs by eliminating joint sealing for those projects. A reduction in traffic delays during sealant maintenance and increased worker safety are possible benefits from the elimination of sealants where they are not found to be cost-effective.

SCOPE OF WORK: This project is intended to address the following questions:

- What is the effect on long-term pavement performance of unsealed transverse joints in concrete pavements with different pavement cross sections and slab dimensions, traffic levels, and climatic conditions?
- What is the effect of different transverse joint sealant materials and configurations on the long-term performance of concrete pavements in various climatic conditions (climatic zones)?
- Is sealing contraction joints cost-effective for different pavement designs and materials over a range of climatic zones and traffic levels?

PERIOD OF PERFORMANCE: Not started, expected duration: 3 years

COST: $400,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: ProTech Engineering/Kathleen T. Hall, Ph.D.

STATUS: Contract was awarded in March 2003.

TITLE: Revision of I-Slab 2000 for Subbase/Pavement Interaction

TASK/STUDY NUMBER: Task 10(00)

OBJECTIVE: Revise the I-Slab 2000 analysis program to account for the interaction between the concrete slab and the underlying layer.

BACKGROUND: One of the main drawbacks of many finite element programs is their ability to adequately model the interface condition between the portland cement concrete (PCC) slab and the underlying layer. The existing finite element programs for pavement analysis assume either zero or full bond (no slippage) for the interface condition. In reality, the amount of layer slippage under a heavy wheel load is somewhere between these two extremes. Having the capability of modeling and specifying the varying levels of slippage between the slab and an underlying layer would greatly improve the ability to fine-tune concrete pavement design.

SCOPE OF WORK:
- Modify I-Slab 2000 analysis program and graphical user interface to allow modeling of concrete slab and underlying layer to better account for the interaction.
- Perform trial runs and sensitivity studies to ensure that the program is performing as expected.
- Deliver revised program and documentation for an unlimited license for use by ACPA.

PERIOD OF PERFORMANCE: June 2, 2000–September 2, 2001

COST: $40,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: ERES Consultants, Inc./Lev Khazanovich

STATUS: An appropriate mathematical model has been identified, involving a 40-degree-of-freedom stiffness element to address layer interaction. The I-Slab 2000 computer code has been modified to include the layer interface model. The I-Slab 2000 graphical user interface has been modified to allow the user to enter new structural model parameters (friction parameters, horizontal joint stiffness, horizontal restraint).

Testing and verification of the program is now under way. The graphical post-processor has been modified to better report the output of the new computations.

The user's guide and installation CD-ROM were received on August 14, 2002. New model verification is under way at the Minnesota DOT and the Michigan DOT/Michigan State University. The program will be released to the public after verification and after any necessary corrections are made.

TITLE: Workshops on Concrete Pavement Technology for State DOT Pavement Engineers

TASK/STUDY NUMBER: Task 11(00)

OBJECTIVE: Conduct 2-day workshops on current concrete pavement technology for State DOT engineers.

BACKGROUND: Improvements to the design, construction, rehabilitation, and asset management of concrete pavements will only be made when technological advances are put into use. State DOTs are the primary agents for such advancement since they are responsible for building and maintaining the great majority of highways in the United States. Therefore, it is essential for key State DOT engineers to become familiar with new concrete pavement technology. One effective method for transferring technology is through workshops. Workshops are effective when leading authorities present new technology, followed by ample time for participants to share experiences and viewpoints. However, this format is only effective in changing DOT practices when key State DOT staff members are participants. It is important that the appropriate representatives from the State DOTs, as well as pavement experts from the FHWA regional resource centers, participate.

Additionally, college professors of civil engineering can educate students on new technologies. University professors who teach pavement technology are invited for updates on the latest advances in concrete pavements, including products and findings from CPTP.

SCOPE OF WORK:
- Plan, organize, and conduct an annual 2-day workshop on concrete pavement technology for State DOT pavement engineers.
- Plan, organize, and conduct an annual 2-day workshop on concrete pavement technology for college professors teaching pavement engineering.

START DATE:
- June 2000 for 2000 workshop for DOT pavement engineers; 2000 workshop held August 10–11, 2000.
- April 2001 for 2001 workshop for DOT pavement engineers; 2001 workshop held June 28–29, 2001.
- April 2001 for 2001 professor's workshop; 2001 professor's workshop held June 18–20, 2001.

DURATION: Annual State DOT workshops held each year for 4 years. Professor's workshop held in 2001.

COST: $60,000 in fiscal year (FY) 2000; $105,000 in FY 2001

CONTRACTOR/PRINCIPAL INVESTIGATOR: ACPA

STATUS: The first State DOT workshop, entitled "Concrete Pavement Design–2000 and Beyond," was held August 10–11, 2000, in Breckenridge, CO. Many positive comments were received from participants regarding the workshop's format, discussion topics, and the quality of the presentations.

The second State DOT workshop was held in San Francisco, CA, June 28–29, 2001. The 2001 professor's workshop took place June 18–20, 2001, in Skokie, IL.

No further activity is anticipated.

TITLE: Develop a Plan to Investigate the Impacts of Pavement Cracking on Long-Term Performance

TASK/STUDY NUMBER: Task 12(00)

OBJECTIVE: Conduct a thorough literature search and compile a summary report on the impacts of pavement cracking on long-term concrete pavement. Prepare a research plan to address the impacts of pavement cracking on long-term performance.

BACKGROUND: Uncontrolled cracking in concrete pavements can be the result of many factors. While such cracking is undesirable, the long-term effects on pavement performance and durability are not clear. Key questions include:

- Which types of cracks affect pavement performance and durability?
- How does cracking affect the performance of pavements built on different bases?
- How many cracks can be tolerated without significantly affecting ride quality?
- When is crack repair or slab replacement needed?

SCOPE OF WORK: Purchase orders issued to two researchers with recognized expertise to perform the literature search and prepare independent plans for the needed research.

PERIOD OF PERFORMANCE: October 2000–November 2000

COST: $10,000 ($5,000 each)

CONTRACTOR/PRINCIPAL INVESTIGATOR: Construction Technology Laboratories, Inc./Shiraz Tayabji and ERES Consultants, Inc./Michael Darter

STATUS: The feasibility studies were completed and both concluded that enough information was available to determine the potential for success of a study on the impact of cracking on pavement performance. This task has been completed.

TITLE: Determine Actual Life-Cycle Costs

TASK/STUDY NUMBER: Task 13(00)

OBJECTIVE: Select and perform comprehensive life-cycle cost analyses for three specific highway sections and distribute reports presenting the results.

BACKGROUND: Many State DOTs have developed life-cycle cost-analysis models. Some additional guidance has been provided by FHWA; however, in general, life-cycle cost models vary considerably across the United States. As with any prediction model, actual performance information is needed for verification and calibration. Very little actual life-cycle cost information is available to check the reasonableness of LCCA models.

SCOPE OF WORK:
- Identify three candidate highway sections for LCCA.
- Thoroughly review historical data, compiling the actual schedule and the costs of building and rehabilitating these sections of highway.
- Establish the actual life-cycle costs of the highway sections using established LCCA principles and prepare the appropriate reports.

PERIOD OF PERFORMANCE: August 1, 2000–January 31, 2002, ERES Consultants, Inc. (1.5 years)

COST: $180,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: ERES Consultants, Inc.

STATUS: This 100-percent industry-funded project will be completed by IPRF. Deliverables will be provided to FHWA.

TITLE: Aurora 2000 Pavement System Analysis Tools

TASK/STUDY NUMBER: Task 14(00)

OBJECTIVE: Develop a set of system analysis tools for pavements.

BACKGROUND: The work was initiated in 1997 to develop a state-of-the-art, mechanistic pavement design selection and evaluation system. During the course of the work, it has evolved into a system of tools that address planning, design, construction, and economics. These tools are packaged in a common, user-friendly Microsoft® Windows® interface.

SCOPE OF WORK: Products include:
- Aurora 2000 system software.
- Decisionmaker derivative software (utility theory).
- Traffic management and cost analysis tool.
- Specification/special provision development tool.

START DATE: October 1997

DURATION: 3 years

COST: $2,610,000 (IPRF/industry funds)

CONTRACTOR/PRINCIPAL INVESTIGATOR: The Transtec Group, Inc./Robert Otto Rasmussen, Ph.D.

STATUS: As the result of a technical review by the project panel, the final deliverables were submitted on September 29, 2000. Software was demonstrated to Federal and State DOT and industry representatives at the San Francisco Technology-Transfer Workshop held June 28–29, 2001. The project has been completed.

A contract to perform an independent evaluation of Aurora 2000 currently is being advertised.

TITLE: Long-Term Plan for Concrete Pavement Research and Technology

TASK/STUDY NUMBER: Task 15(01)

BACKGROUND: Task 15 was originally conceived and initiated to address the need for focus and direction in the CPTP activities beyond the current work and resources. The long-term plan being developed through this endeavor will chart a path from the current state-of-the-practice to a new generation of concrete pavements. It is intended to guide concrete pavement research, development, and technology activities both within and outside of CPTP and FHWA's post-TEA-21 Infrastructure Technology Program.

SCOPE OF WORK:
- Develop long-term plan.
- Develop action plan to implement the long-term plan.

START DATE: June 2001 (IPRF), February 2003 (resumption under FHWA)

END DATE: February 2005

COST:

Pre-2003:	$220,831
Current:	$413,471 (Federal share)
	$103,373 (matching funds)
Total:	$737,675

CONTRACTOR/PRINCIPAL INVESTIGATOR: Iowa State University/Ted Ferragut

STATUS: Work on this project was terminated on June 6, 2002, because of the termination of the IPRF cooperative agreement. Accomplishments prior to this termination included the following:
- Presentations to and requests for input from:
  1. Three committees at the TRB annual meeting, in addition to session 345.
  2. Concrete pavement industry representatives in Iowa, Michigan, Nebraska, and Virginia.
  3. International Center for Aggregate Research.
- Completion of a first draft catalogue of recently completed, ongoing, and planned research.
- Outline of plan objectives.
- Discussions with the project panel on April 3, 2002, resulting in further refinement of the approach and agreement on schedule adjustments arising from the earlier suspension, and the addition of the research data base to the list of project deliverables.

A new cooperative agreement between Iowa State University and FHWA was signed in February 2003. The research team is updating their detailed work plan in preparation for review by, and discussion with, the project panel in early April 2003.

TITLE: Smoothness Criteria for Concrete Pavements

TASK/STUDY NUMBER: Task 16(01)

OBJECTIVES:
- Determine which profile characteristics are objectionable, how to measure them, what causes them, and how to avoid creating them.
- Determine the limits and value of smoothness specifications for concrete pavement.
- Determine a method to identify and correct localized roughness features in concrete pavement.

BACKGROUND: Research has shown that concrete pavements built smooth initially stay smooth longer than pavement initially built rough. To provide smoother pavements, many States use incentive and disincentive provisions in their construction contracts. These provisions provide a financial incentive to contractors who exceed the required pavement smoothness while penalizing contractors who build a pavement that is rougher than specified. Forty-five of fifty-two SHAs use specifications for pavement smoothness for construction acceptance of concrete pavement. Of SHAs using smoothness specifications for concrete pavements, most currently use a profilograph or other response-type roughness meter. However, there is growing trend toward changing the measurement device to an inertial profiler and toward more advanced roughness indices (International Roughness Index [IRI]). The American Association of State Highway and Transportation Officials (AASHTO) is currently considering adoption of a provisional standard for pavement smoothness based on inertial profilers and IRI.

While there is substantial experience with inertial profilers and IRI for pavement management, the use of inertial profilers and IRI as a construction QC/QA device is relatively new. There are aspects of using inertial profilers and IRI for quality control and acceptance of concrete pavement that require a more thorough understanding before improved pavement smoothness specifications can be implemented on a widespread basis.

SCOPE OF WORK: Researchers are requested to investigate the following questions:
- Which profile characteristics of new (or newer) concrete pavements are objectionable to highway users?
- What are the most common objectionable profile characteristics present in new concrete pavement? What is causing them and how do we avoid creating them?
- What is the best approach to measure these characteristics?
  1. How do concrete pavement joints and texture impact these measurements?
- How smooth is "smooth enough"?
  1. What is the limit of the user's perception?
  2. What improvement in performance (extended service life) is obtained with improved smoothness?
  3. What is the value of improved smoothness?
- How do we *identify and correct* localized roughness features in new concrete pavement?
  1. What is the cost of localized roughness features over a pavement's life cycle?

START DATE: March 2003

DURATION: 30 months

COST: $500,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: Soils and Materials Engineers/Starr Kohn

STATUS: Contract awarded on April 2003.

TITLE: Subbase Design

TASK/STUDY NUMBER: Task 17(01)

STATUS: Rejected by FHWA because this was proposed as a noncompetitive agreement funded by the Portland Cement Association.

TITLE: Roller-Compacted Concrete for Asphalt Overlays

TASK/STUDY NUMBER: Task 18(01)

STATUS: Rejected by FHWA because it examines asphalt overlays, and this is a concrete research program.

TITLE: Communications Services for the Concrete Pavement Technology Program

TASK/STUDY NUMBER: Task 19(01)

OBJECTIVE: Improve the communications program for CPTP.

BACKGROUND: Information about the progress and activities of CPTP should be provided to the program sponsors and the general public. In addition, assistance is needed in the preparation of products from the research program in order to make application easier by the intended users in government and industry.

SCOPE OF WORK: Develop a communications plan and provide professional communications services to IPRF and FHWA.

START DATE: June 2001 (anticipated), revised to February 2002

DURATION: 3 years

COST: $100,000 (2001); $175,000 (2002); $175,000 (2003)

CONTRACTOR/PRINCIPAL INVESTIGATOR: To be determined by open competition.

STATUS: A Request for Proposal (RFP) was issued. Three proposals were received and sent to the panel members. The evaluation panel meeting scheduled for August 30, 2001, was postponed. Work on this project was terminated on June 6, 2002, because of the termination of the IPRF cooperative agreement. The scope of work for this task has been included in proposed task 65: Technology Transfer, Deployment, and Delivery for CPTP.

TITLE: Mobile Concrete Laboratory

TASK/STUDY NUMBER: Task 51(99)

OBJECTIVE: Introduce Federal, State, and local transportation personnel to state-of-the-art concrete technology for materials selection and mixture design, as well as for field and laboratory testing.

BACKGROUND: Transferring new technology to highway construction agencies and contractors is often a slow process. The Mobile Concrete Laboratory (MCL), initiated by FHWA, attempts to shorten the acceptance time for new technologies and research through further refinement of these technologies. In many cases, the technologies are validated in the field on actual projects, results are documented, and recommendations are made to the participating agency and the researcher. New technologies are also introduced to SHAs and industry through demonstrations at the job site, equipment exhibitions at events attended by the decisionmakers, teaching personnel how the new technology can be used, and publishing articles on the results of the MCL activities.

SCOPE OF WORK: The staff of MCL markets the MCL services to State DOTs and schedules participation in construction projects. For each project, MCL develops a test plan incorporating both traditional concrete testing and the new technologies featured by the MCL staff in concert with the host agency and project contractor. Data gathered by MCL is analyzed and a report on the project is prepared for the host agency's use.

The focus of MCL for FY 2003 is to support FHWA's Office of Pavement Technologies' Long-Life Pavement Technology Program.

START DATE: October 1, 2002

DURATION: 3 years (base year plus 2 option years)

COST: $1.9 million, including travel costs for 3 years

CONTRACTOR/PRICIPAL INVESTIGATOR: SaLUT, Inc./Jon Mullarky and Leif Wathne

PERFORMANCE MEASURES: Performance measures for FY 2003 include: (1) providing expertise through MCL for calibration and validation of 2002 Pavement Design Guide material models in two or three States, (2) providing support for evaluation and implementation of PRS in two or three States, and (3) providing support to States using the best available QC/QA systems in three States.

TIMELINE FOR COMPLETION: Current contract will expire on September 30, 2005.

STATUS: During FY 2003, MCL has provided services to the LTPP program to evaluate the use of the impact-echo technique on existing concrete pavements to measure thickness in lieu of taking destructive cores. MCL has eight ongoing equipment loans to highway agencies evaluating these new technologies. The laboratory was on display at the Concrete Paving Conference in Austin, TX. The MCL staff also arranged and made technical presentations at an Admixture Workshop for New Jersey DOT, a High-Volume Fly Ash Workshop for Colorado DOT, and a Mixture Design Workshop at the Fourth Annual Pennsylvania Concrete Seminar. Technical presentations were made at the Texas Concrete Pavement Workshop; the Self-Consolidating Conference in Chicago, IL; the ACPA First Annual Concrete Pavement Conference in Albany, NY; and the SCAN Conference in Raleigh, NC.

At this time, MCL is committed to FY 2003 projects in Florida and New York, and continued work in Pennsylvania. Requests have been received for MCL participation in field projects in California, Indiana, Iowa, New York, and North Carolina. Approximately 28 percent of the available base year funds have been expended and 33 percent of the work has been completed.

Title: Quality Concrete Rehabilitation and Preservation (Special Project 205 [SP-205])
TASK/STUDY NUMBER: Task 52(98)

OBJECTIVE: SP-205 will develop guidance on concrete pavement rehabilitation and repair techniques as well as strategies that emphasizes the *do's and don'ts*, and the *why* and *when* for concrete preservation and rehabilitation (CPR) and preventive maintenance of concrete pavements.

SCOPE: SP-205 will reexamine sites and techniques studied by FHWA in the mid-1980s, as well as test and evaluate new and innovative CPR techniques and strategies through testing and evaluation projects. The rehabilitation and maintenance strategies considered are full-depth patching, partial-depth patching, subsealing, joint resealing, retrofit load transfer, and grinding and grooving.

START DATE: Program was started in 1997.

DURATION: Ongoing

COST: $300,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: Various SHAs

PERFORMANCE MEASURES: Number of State DOTs adopting improved CPR techniques.

TIMELINE FOR COMPLETION: See table below.

STATUS: Ongoing

UPDATE: Field reviews have been completed. The field demonstration projects are summarized below:

SP-205: Project Status

State	Project Description	Construction Date	Final Report Due
MN	Retrofit load transfer, short dowels, type II cement	1998	2003
OR	Mill abrading and shot basting to remove wheel ruts caused by studded tires	1998	Received 1999
WI	Partial-depth repair techniques	1999	2004
OK	Monolithic bonded concrete overlay and dowel bar retrofit	1999	2003

TITLE: High-Performance Concrete Pavements (Test and Evaluation Project 30 [TE-30])

TASK/STUDY NUMBER: Task 53(98)

OBJECTIVE: The immediate goal of the TE-30 project is to construct selected highway projects to explore the applicability of innovative concrete pavement design and construction concepts in the United States. The long-range goal is the improvement of concrete pavement design, materials, and construction technology and equipment through innovation, research, training, and evaluation of promising pavement technology developments in other countries.

BACKGROUND: TE-30 has been an active FHWA project since 1996.

SCOPE OF WORK: Projects submitted by SHAs for TE-30 should address one or more of the following issues: increasing service life, decreasing construction time, lowering life-cycle costs, lowering maintenance costs, constructing ultrasmooth ride-quality pavements, incorporating recycled or waste products while maintaining quality, or using innovative construction equipment or procedures. Curing, curling, and warping evaluations; recycling; alternative concrete mixes Recycled Asphalt Pavement (RAP) (as aggregate, kiln dust, etc.); and well-graded concrete mixes will be priority activities.

START DATE: 1995

DURATION: Ongoing

COST: Approximately $500,000 annually

CONTRACTOR/PRINCIPAL INVESTIGATOR: Various SHAs

PERFORMANCE MEASURES: Incorporation of findings into standard practice by the State.

TIMELINE FOR COMPLETION:

TE-30: High-Performance Concrete Pavements

State	Description	Construction Date	Final Report Due
SD	Thin pavement with polyolefin fibers	1996	Received 1998
IA	Improved PCC mixes and mixing times	1996	Received 1998
WI	Alternate dowel bar materials, alternate cross sections	1997	Spring 2004
WI	PCC surface texture and noise study	1997	Received 2001
IL	Alternate dowel bars and installing traffic classifiers	1997, 1999	2002
OH	Various sealant types or no sealants	1997–1998	2003
OH	Ground granulated blast furnace slag in concrete pavement	1997–1998	March 2002
OH	Alternate dowel bar materials and dowel bar spacing	1997	2002
KS	Mix designs with recycled asphalt and two-lift construction, alternate dowel materials, 12 sections	1997	2003
IA	Alternate dowel bar materials	1997	2003
MO	Fiber-reinforced concrete pavement	1998	2003
VA	High-durability concrete mixes for jointed portland cement pavements (JPCP2)	1998–1999	2004
VA	High-durability concrete mixes for continuously reinforced concrete pavements (CRCP), high reinforcement	2000–2001	2006
MN	60-year design life JPCP	2000	2005
MS	Resin-modified pavement	2001	2006
IA	Fly ash stabilization of PCC pavement subgrade	2000	2005
MN	Low-volume road design, curling and warping	2000	2003
MD	Fiber-reinforced concrete mixes and low-shrinkage concrete	2001	2006

KS	Super-smooth pavement: equipment and methods	2001	2006
IN	Long-life PCC pavement	2002	2007
WI	50-year PCC pavement design	2002	2007
CA	Precast, post-tensioned pavement on Interstate 10 (I-10)	2002	2004
OH	High-durability concrete mixes for JPCP, curing techniques	2003	2005
IA	Elliptical fiber-reinforced polymer (FRP) dowel bars	2002	2005
IA	Guidelines for fly ash stabilization of subgrade for PCC pavement	2002	2004

UPDATE: TE-30: High-Performance Concrete Pavements (HPCP) has funded approximately 25 projects since 1996. Construction of the candidate projects, once approved, are handled in accordance with existing Federal-aid procedures. Evaluation of the projects is conducted by various State agencies. A summary report was published by FHWA in March 2002.

TITLE: Repair and Rehabilitation of Concrete Pavements

TASK/STUDY NUMBER: FHWA Task54(99)

OBJECTIVE: Develop systematic, user-friendly guidelines to select:
- The better approach between the areas of repair and rehabilitation
- Specific materials and techniques to optimize service lives, considering performance and cost.

BACKGROUND: Many alternatives exist for the repair and rehabilitation of concrete pavements. Comprehensive guidance will be developed to enable a systematic evaluation and selection. Such a procedure must consider the properties and performance of the various treatments, the current condition, and the rate-of-change of the condition of the pavement under consideration. A process is needed to direct the engineer through the series of decisions leading to the proper choice between repair and rehabilitation, and the selection of the optimal materials and techniques.

SCOPE OF WORK: Information will be searched to determine the current state-of-knowledge and state-of-the-practice for repair and rehabilitation of concrete pavement including jointed plain concrete pavement (JPCP), jointed reinforced concrete pavement (JRCP), and continuous reinforced concrete pavement (CRCP). Next, a set of guidelines will be developed to: (1) evaluate existing pavement, (2) select between repair and rehabilitation, and (3) select specific materials and technique(s) for optimal pavement performance and cost. The finalized guidelines will be incorporated into user-friendly software.

PERIOD OF PERFORMANCE: February 2000–December 2003

COST: $501,674, plus an additional $92,000 to extend the project 9 months in order to make products comply with Section 508 of the Rehabilitation Act: Electronic and Information Technology Accessibility Standards), to work on a precast repair of CRCP in Houston, TX, and to cooperate with Europe on their format project, "Pavement Strengthening."

CONTRACTOR/PRINCIPAL INVESTIGATOR: Texas A&M Research Foundation/Dan Zollinger

PERFORMANCE MEASURES: Establish advisory panel, search literature, provide interim report, evaluate draft guidelines, finalize guidelines, and provide final report and software package.

TIMELINE FOR COMPLETION: Draft final submissions in September 2003; contract completion in December 2003.

STATUS: Costs through January 31, 2003, were $427,634, or about 85 percent of the original planned cost of $501,674. Contractor estimates that about 90 percent of the original work was completed.

A draft version of the Windows-based software was ready with the January progress report. The program does most of what was intended. Version 2.0 will include help screens, plus other small changes. Research efforts will be initiated on variability in pavement performance to help compute life-cycle costs, reconstruction as a treatment option, and analysis of CRCP. A third meeting of the technical working group, with representatives from five State DOTs, the National Cooperative Highway Research Program (NCHRP), and an FHWA field office, will be arranged. A third State DOT (Maryland) should evaluate the guidelines.

A planning meeting will be held with the Houston District (Texas) to further coordinate full- and partial-depth precast repairs for CRCP.

TITLE: Accelerated Load Tests of Ultrathin Whitetopping

TASK/STUDY NUMBER: FHWA Task 55(99)

OBJECTIVE: Construct and test the UTW sections at FHWA's ALF so that data can be collected to evaluate and develop design procedures. Note that an IPRF contractor has developed an updated ACPA UTW design method based on stationary finite element models.

BACKGROUND: FHWA and ACPA began a cooperative agreement in 1998. Response data were collected on eight sections of UTW at ALF.

SCOPE OF WORK: Existing asphalt test sections were milled out to two depths at ALF and UTW was placed using concrete with and without fibers at three different joint spacings. Instruments were placed to measure strains at various locations. The lanes were then loaded using the ALF device.

PERIOD OF PERFORMANCE: 1998–2003

COST: $325,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: FHWA/James Sherwood, Research and Development (R&D)

PERFORMANCE MEASURES: Instrument and construct the UTW test sections, load and monitor the sections, and supply the data to IPRF for further analysis and design. Evaluate the design methods.

TIMELINE FOR COMPLETION: The work has been completed, except for the final report due in 2003.

STATUS: Field tests have been completed. About $325,000 in contract funds were used to operate the two ALF devices for about 18 months of testing, from May 1998 to December 2000. The FHWA principal investigator is preparing a final FHWA report on the project.

UPDATE: The loading of the eight UTW lanes and data collection have been completed, including development of an ALF UTW data base. Assistance continues to be given to ACPA and their contractors regarding data analysis. About 100 more 150-mm cores were extracted to conduct the Iowa shear test for bonding between the PCC and hot-mix asphalt concrete (HMAC) materials, and to determine the shear strengths of the existing HMAC layers. In practically every case, the bond strength was higher than the shear strength of the HMAC. Sections were removed in spring 2002 for construction of the next ALF experiment on modified asphalt concrete pavements.

TITLE: TFHRC Portland Cement Concrete Pavement (PCCP) Laboratory Studies

TASK/STUDY NUMBER: FHWA Task 56(99)

OBJECTIVE: Conduct studies of concrete materials and concrete behavior in both the plastic and hardened states to pursue the goals and advance the technology of CPTP.

BACKGROUND: The FHWA Office of Infrastructure R&D maintains a set of laboratories and operating staff to conduct relevant research under the guidance of the PCCP Team. Studies are conducted, as necessary, to develop new tests, verify tests and procedures coming out of contract studies, and further develop tests and procedures to prepare them for the next step in the delivery process. Individual projects are described on separate pages designated by alphabetical code under task 56. Thus, the first study listed is subtask 56A, and so on. The laboratory also provides technical assistance to States, MCL, and other researchers at TFHRC.

SCOPE OF WORK: Depending on the needs of the program being addressed, projects conducted can range from something as simple as verification testing of fully developed test methods to developing from concept to completion test methods and procedures to fill a need in CPTP. Current and planned projects include: ongoing thermal coefficient testing of concrete for the LTPP program data base, freeze/thaw testing of concrete with marginal air-void systems, development of a rapid test for alkali-silica reactivity, evaluation of the shrinkage susceptibility of paving concretes, evaluation of the vibrating slope apparatus (VSA) for measuring the workability of paving (stiff) concretes, the effects of aggregate shape on workability and other properties, and the effects of rapid hydration and accelerated curing on concrete properties.

PERIOD OF PERFORMANCE: 1999–2003

COST: $480,000 in FY 2003

CONTRACTOR/PRINCIPAL INVESTIGATOR: FHWA/Marcia Simon, PCCP Laboratory Manager

STATUS: Work in progress.

UPDATE: The mixture optimization project has been completed. The final report and Concrete Optimization Software Tool (COST) user's guide have been submitted for editorial review and publication. Phase II of freeze-thaw testing is under way and will be completed by December 2003. Alkali-silica reactivity (ASR) concrete prisms is under way in both standard and modified versions; however, equipment problems have delayed the testing by several months. Testing will be completed in April 2004. Thermal coefficient testing is being continued using the test developed in house (AASHTO Provisional Standard TP-60-00). Three second-generation versions of the U.S. Army Corps of Engineers (USACE) workability device were constructed and are being used for further laboratory and field evaluation at TFHRC, the University of Texas, and Iowa State University. The shrinkage study will begin in 2003 after installation of the temperature/humidity controls is completed. Two new studies are proposed to begin in FY 2003 as the freeze-thaw study and VSA evaluation are being completed. These proposed studies involve the effects of aggregate shape on workability and other properties, and the effects of rapid hydration and accelerated curing on concrete properties. The objectives of these two studies will be reviewed in light of NCHRP projects involving similar subject matter before proceeding. In addition to planned research studies, assistance to MCL, State DOTs, and other researchers at TFHRC is provided when needed.

TITLE: TFHRC PCCP Laboratory Studies—Development of Standard Test for Concrete Coefficient of Thermal Expansion

TASK/STUDY NUMBER: FHWA Task 56-A(99)

OBJECTIVE:
- Develop a standard test for measuring the coefficient of thermal expansion of concrete (CTE).
- Use that test to measure the CTE of a series of cores from pavements in the LTPP program.

BACKGROUND: CTE is a characteristic determined by the LTPP program to have a potential influence on the performance of pavements. As a result, the concrete laboratories at TFHRC were assigned the task of developing a standard test for this property since none existed in either AASHTO or ASTM.

SCOPE OF WORK: Available information was searched to determine how this concrete characteristic was being measured. Based on this information, the most feasible approach was selected for developing a standard test that would be repeatable, easy to conduct, and relatively inexpensive to set up. After testing and validation, the test will be used to characterize several thousand concrete pavement cores collected in the LTPP program.

PERIOD OF PERFORMANCE: 1999–2007

COST: $76,000 in FY 2003

CONTRACTOR/PRINCIPAL INVESTIGATOR: FHWA/Marcia Simon, PCCP Laboratory Manager, and SaLUT, Inc./Jussara Ramadan, engineer contracted to PCCP laboratories

PERFORMANCE MEASURES: Approximately 1100 cores have been tested to date. Testing averages approximately 40 cores per month.

TIMELINE FOR COMPLETION: Approximately 1200 cores remain to be tested. At the current rate, testing will be completed in 2007.

STATUS: Work in progress, 55 percent completed.

UPDATE: A standard CTE test has been developed and finalized. It involves: (1) sawing the cores to a standard length (178 mm [7 inches]), (2) grinding the ends parallel, (3) soaking the cores to reach saturated surface dry condition, (4) mounting the core in a measuring frame, (5) putting the setup in a controlled-temperature water bath, and (6) obtaining exact specimen length change and temperature change caused by a change in the temperature of the bath of 40 degrees Celsius (°C). This test is now AASHTO Provisional Standard TP-60-00, as listed in the *AASHTO Provisional Standards: May 2002 Edition*. At least partially because of this work, the new *2002 Design Guide: Design of New and Rehabilitated Pavement Structures* will include the CTE of the concrete as one of the input variables. Tests continue to be conducted on the LTPP cores, with an estimated 4 years of testing remaining. New water baths were purchased to increase testing throughput.

TITLE: TFHRC PCCP Laboratory Studies—Concrete Mixture Optimization Using Statistical Methods

TASK/STUDY NUMBER: FHWA Task 56-B(99)

OBJECTIVE:
- Investigate the feasibility of using statistical experimental design methods in concrete mixture proportioning.
- And if these methods are feasible, develop an interactive Web site that will assist interested parties in using these methods.

BACKGROUND: High-performance concrete (HPC) mixtures typically contain at least six component materials and may be required to meet several performance criteria simultaneously. While the American Concrete Institute (ACI) 211 guide for proportioning concrete mixtures and other procedures are good starting points for concrete proportioning, they do not provide information on the optimal proportions for meeting several performance criteria at the same time. As a result, trial and error, considering one factor at a time, is the usual process. This approach can be inefficient, costly, and may not result in the best combination of materials. Statistical procedures have been developed for optimizing mixtures in other industries. The feasibility of applying this technique to concrete needs to be explored.

SCOPE OF WORK: In phase I of the project, the design, performance, and analysis of two laboratory experiments to identify one or more concrete mixtures that meet several performance criteria at a minimum cost will be conducted. Several statistical approaches will be tried. If one of the approaches proves to be feasible, an interactive Web site will be developed to help the user select trial batches.

PERIOD OF PERFORMANCE: 1999–2001

COST: $0 in FY 2003

CONTRACTOR/PRINCIPAL INVESTIGATOR: FHWA/Marcia Simon, PCCP Laboratory Manager

PERFORMANCE MEASURES: Web site and user's guide (completed, publication of user's guide is pending), and project report.

TIMELINE FOR COMPLETION: April 2003

STATUS: Completed except for publication of final report and user's guide.

UPDATE: Laboratory work and interactive Web site software development have been completed. The interactive Web site called Concrete Optimization Software Tool and user's guide are accessible online at http://ciks.cbt.gov/cost. The software will also be installed in the FHWA MCL and on the TFHRC Web site. Final project report and a user's guide were submitted for editorial review in January 2003.

TITLE: TFHRC PCCP Laboratory Studies—Freeze-Thaw Resistance of Concrete With Marginal Entrained Air Content

TASK/STUDY NUMBER: FHWA Task 56-C(99)

OBJECTIVE:
- Investigate freeze-thaw durability of concrete with marginal air contents.
- Investigate improvements in damage assessment of freeze-thaw test specimens.

BACKGROUND: An adequate entrained air-void system in concrete is considered necessary for resistance to distress caused by freezing and thawing. Typical air-void parameters are 6 percent air, a specific surface greater than 23.6 mm^{-1} and a spacing factor of 0.203 mm or less. However, there is evidence that some concretes not meeting these criteria may be freeze-thaw durable, and there is debate as to whether some HPC with a sufficiently low water-to-cement (w/c) ratio requires air entrainment. The Strategic Highway Research Program (SHRP) project on freeze-thaw (F/T) durability proposed a modified testing procedure using terry-cloth covers and the use of the "quality factor" for predicting the performance of concrete F/T specimens. These modifications are being investigated to assess their usefulness in improving freeze-thaw testing.

SCOPE OF WORK: Concrete mixtures with marginal air contents will be tested using standard ASTM C666 procedures, as well as the modified terry-cloth procedure suggested in the SHRP study. The quality factor will be evaluated as to its ability to predict the durability of the concrete at a fewer number of cycles. Additional series of concrete mixtures will be tested as needed.

PERIOD OF PERFORMANCE: 1999–2003

COST: $45,000 in FY 2003

CONTRACTOR/PRINCIPAL INVESTIGATOR: FHWA/Marcia Simon, PCCP Laboratory Manager

PERFORMANCE MEASURES: Phase II testing (December 2002) and project report (June 2003).

TIMELINE FOR COMPLETION: Estimated completion date is June 2003.

STATUS: Work in progress, 75 percent completed

UPDATE: Phase I was completed. In this phase, concretes with air contents of approximately 3 percent withstood 300 cycles of freeze-thaw testing. The SHRP terry-cloth procedure was, in most cases, as severe as procedure A, and is less variable than procedure B. Mass loss was considerably greater in procedure A (because of scaling). Phase II involves testing of concretes with air contents ranging from 2.5 to 4.5 percent and w/c ratios of 0.40 to 0.50 with two different types of air entraining admixtures. The first part of phase II was completed and the results indicate similar results for freeze-thaw durability. Further data analysis is under way to assess the relationship of air-void parameters to durability and the use of the quality factor for assessing damage. Because of continuing problems with steel containers and difficulty obtaining new ones, a study comparing terry cloth and containers at a range of air contents (2.7 to 4.7 percent) was performed to assess the relative severity of testing. If the testing results are comparable, further testing will be conducted using terry cloth in lieu of containers. The comparison study was completed in December 2002. The results indicate comparable durability factors, with terry cloth having slightly higher values, except for the case of nonair-entrained concrete, where terry cloth was more severe. Specimens in containers experienced moderate to severe scaling (typically 2 to 3 percent mass loss) regardless of air content. The scaling probably had some effect on the durability factor. Surprisingly, nearly all of the air-entrained test beams, even the 2.7-percent air mix, had durability factors greater than 80 percent after 300 cycles. This result corroborates the phase I results. Further investigation of the air-void parameters of these mixes is under way, along with analysis of the quality factor from the frequency response data. A set of tests using the air-void analyzer to determine the air-void parameters of the fresh concrete is planned for spring 2003.

TITLE: TFHRC PCCP Laboratory Studies—Development of a Mix-Specific ASR Test Method

TASK/STUDY NUMBER: FHWA Task 56-D (99)

OBJECTIVE: Identify a fast, reliable test for assessing the ASR potential of concrete mixtures.

BACKGROUND: There is currently no rapid test method that is claimed to evaluate the ASR susceptibility of concrete mixtures. ASTM C1260 specifically states that it is to be used to assess aggregates and not combinations of aggregates and cementitious materials (although some researchers have investigated its use for that purpose). The concrete prism test developed in Canada (ASTM C1293) is more realistic in that it tests concrete rather than mortar; however, it can take a year or more to perform. Other methods have been suggested or tried, but are not recommended because of limited data.

SCOPE OF WORK: The first phase of this work will look at issues with the mortar bar test (ASTM C1260), including the effects of different cements and specimen size. The second phase will use concrete prism tests at 38 °C and 60 °C in a test protocol, varying w/c ratios, fly ash replacement level, and lithium dosage for a given aggregate. The test results will be used to estimate a predictive model that can be used to predict expected ASR expansion anywhere within the ranges used for the w/c ratio, fly ash, and lithium.

PERIOD OF PERFORMANCE: 1999–2003

COST: $66,000 in FY 2003

CONTRACTOR/PRINCIPAL INVESTIGATOR: FHWA/Marcia Simon, PCCP Laboratory Manager

PERFORMANCE MEASURES: Prism testing (February 2004), interim report on prism testing (December 2003), and final report (April 2004).

TIMELINE FOR COMPLETION: Estimated completion date is April 2004.

STATUS: Work in progress, 30 percent completed.

UPDATE: Phase I results indicate that the use of different cements can have a significant effect on the expansion measured in ASTM C1260, even if the cements meet the criteria set forth in the test method. It is suspected that MgO in the cement could be the cause. A paper documenting this work was presented at the 11th International Conference on Alkali-Aggregate Reactivity in June 2000. Phase II is under way. Tests are being performed for 1 year at 38 °C, for 3 months at 60 °C, and for three months at 60 °C using modified prisms with longitudinal holes to allow easier moisture ingress (developed at the University of New Hampshire). Variables include w/c ratios (0.4 to 0.5), percentage of Class F fly ash replacement (0 to 30 percent), and the percentage of the recommended lithium dosage (0 to 100 percent). Testing at 38 °C began in August 2002. Currently, repeated mixing of specimens at 38 °C is being performed because of concerns with some early readings. Testing at 60 °C has been delayed because of equipment problems with the environmental chamber, which will be resolved by mid-March 2003. Casting and testing of prisms at 60 °C will begin in March 2003.

TITLE: TFHRC PCCP Laboratory Studies—Variation of Shrinkage Potential of Portland Cement Concrete

TASK/STUDY NUMBER: FHWA Task 56-E(99)

OBJECTIVE: Assess the shrinkage behavior of PCC paving mixtures and identify mixtures that minimize shrinkage and the associated cracking tendency.

BACKGROUND: Uncontrolled cracking in jointed concrete pavements is an area of concern when it comes to providing long service life without the need for premature repair and rehabilitation. One of the primary properties of the concrete influencing the occurrence of cracking is the amount of shrinkage that the concrete undergoes. It is known that the total shrinkage experienced by PCC depends on a number of factors, such as the aggregate volume fraction, cement properties, and the curing environment. Further study is needed to investigate the effects of the combination of the various concrete components and the curing regimes on concrete shrinkage.

SCOPE OF WORK: The concrete mixtures to be investigated will include typical paving mixtures. Initial investigations will compare different cements (of the same type, e.g., type I) and curing regimes. Further investigations will involve combinations of cementitious materials and varying aggregate volumes. Tests will include restrained shrinkage using the ring test (AASHTO PP34-99)and unrestrained shrinkage (ASTM C157), early-age free shrinkage, and the measurement of evaporable/nonevaporable water. The emphasis will be on monitoring early-age shrinkage (up to 3 days).

PERIOD OF PERFORMANCE: 2002–2004

COST: $48,000 in FY 2003

CONTRACTOR/PRINCIPAL INVESTIGATOR: FHWA/Marcia Simon, PCCP Laboratory Manager, and SaLUT, Inc./Jussara Ramadan, engineer contracted to PCCP laboratories

PERFORMANCE MEASURES: Controlled-environment room setup, initial testing, interim report, phase 2 testing, and final report.

TIMELINE TO COMPLETION: Estimated completion date is December 2004.

STATUS: Project scheduled to begin in FY 2003.

UPDATE: Equipment has been assembled to conduct restrained and unrestrained shrinkage tests and evaporable/nonevaporable water measurement. Installation of temperature and humidity controls for the shrinkage laboratory was delayed and expected completion is by mid-March 2003. Once the controlled-environment room is operational, materials will be obtained and planning/testing will begin.

TITLE: TFHRC PCCP Laboratory Studies—Evaluation of the Workability Test and the Workability of Concrete Paving Mixtures

TASK/STUDY NUMBER: FHWA Task 56-F(99)

OBJECTIVE:
- Evaluate the operation and repeatability of the newly developed workability test device and procedure.
- Use this test to measure the workability of a range of concrete paving mixtures and determine which factors have a primary influence on workability.

BACKGROUND: The slump test measures only one of the concrete properties that influence workability (yield stress). In order to fully define workability, the plastic viscosity of the concrete must also be known. Many concrete rheological devices have been developed; however, none was applicable to the relatively stiff slipform paving concrete. USACE recently developed a workability measuring device for FHWA. VSA quantifies workability by measuring the time it takes for a measured mass of concrete to move out of the chute under a certain vibratory energy.

SCOPE OF WORK: The prototype VSA will be evaluated and tested for ruggedness and repeatability. Design and operational modifications will be made as necessary to improve the device. After any modifications are made, the device will be used to measure the workability of a range of mixtures in the laboratory. Field evaluations will also be performed to correlate the workability index reported by the device to actual workability on the job.

The scope has been expanded based on the results of the initial evaluation. The second-generation VSA built by FHWA will be evaluated in terms of validity and the interpretation of the results. The procedure may be modified from that originally specified by USACE. After validation, the apparatus will be used in a laboratory study of the effects of aggregate shape on workability and other concrete properties.

PERIOD OF PERFORMANCE: 2000–2003

COST: $56,000 in FY 2003

CONTRACTOR/PRINCIPAL INVESTIGATOR: FHWA/Marcia Simon, PCCP Laboratory Manager, and SaLUT, Inc./Jussara Ramadan, engineer contracted to PCCP laboratories

PERFORMANCE MEASURES: Prototype evaluation (completed, report under review), initial evaluation of test factors (completed), shop drawings (completed), construction of new VSAs (completed), evaluation of VSA (January 2003), aggregate effects (April 2003), and report (September 2003).

TIMELINE FOR COMPLETION: Estimated completion date is September 2003.

STATUS: Work in progress, 75 percent completed.

UPDATE: The three new VSAs, with updated electronics and software, were completed in December 2002. Two VSAs were loaned to the University of Texas and Iowa State University for evaluation. The remaining VSA is being evaluated further at TFHRC in this study, which will include assessment of test factors (concrete slump, chute angle, and vibration force), test procedure modifications, and analysis and interpretation methods. Use of FRP instead of steel for the chute (to decrease weight and thus increase the effect of the vibrator) will also be investigated.

TITLE: Computer-Based Guidelines for Concrete Pavements (HIPERPAV II)

TASK/STUDY NUMBER: FHWA Task 57(99)

OBJECTIVE: The improved and expanded software (HIPERPAV II) program includes modules for the prediction of JPCP long-term performance as a function of early-age behavior and the early-age behavior of CRCP. Two recently completed FHWA studies have also been incorporated to provide the capabilities for optimization of concrete mix designs to meet specific performance criteria and to predict early-age behavior of dowel bars in rigid pavements.

BACKGROUND: Previously, FHWA developed a computer program, HIPERPAV, to provide guidance to the pavement engineer in the selection of materials and mixture design, pavement design, and construction procedures to avoid early-age cracking in JPCP. The purpose of this project is to investigate and provide guidance on the performance of JPCP beyond the first 72 hours and to investigate and provide guidance on the early-age behavior of CRCP.

SCOPE OF WORK: Information will be searched in order to determine the current state-of-knowledge and state-of-the-practice of the prediction of long-term behavior of JPCP and the early-age behavior of CRCP.

PERIOD OF PERFORMANCE: 2000–2004

COST: The contract was modified, including task G (workshops and technical support) and task H (further improvement of the HIPERPAV II software). This increased the contract value from $745,250 to $953,343, and extended the period of performance to January 31, 2004.

CONTRACTOR/PRINCIPAL INVESTIGATOR: The Transtec Group, Inc./Robert Otto Rasmussen, Ph.D.

PERFORMANCE MEASURES: Establish advisory panel, complete and evaluate the software in the field (include guidelines from other studies [development of software prototypes for dowel analysis and the mix optimization] in the software), and prepare the final version of the software and the final report.

TIMELINE FOR COMPLETION: Work in progress. The first release of the software will be on April 31, 2003 (will include improvements reflecting the feedback received during the pilot workshop). The second release (final) will be before January 31, 2004, which will include feedback from audiences in the workshops.

STATUS: Work in progress. Three workshops were conducted in Iowa, Michigan, and Pennsylvania. The modifications and improvements being made to the HIPERPAV II software program reflect feedback received from the technical group. The following are the cumulative percentages of work for the different tasks: task G, 90 percent; task H, 0 percent; and other tasks, 100 percent (except for the final report, 98 percent). The cumulative percentage of the amount paid to the contractor is 96 percent.

TITLE: Use of Precast Concrete Panels to Expedite Highway Pavement Construction

TASK/STUDY NUMBER: Task 58-A(98)

OBJECTIVE: Investigate the feasibility of using precast concrete technology as a means to expedite concrete pavement construction.

BACKGROUND: Precast concrete construction methods have been developed that are viable alternatives for applications such as buildings and bridges. One of the primary benefits of precast components is the speed of construction. Precast elements can be cast under controlled conditions at a precasting yard, far in advance of when they will be needed, then stockpiled and transported to the job site as necessary. Allowing time for concrete to cure before opening to traffic is a time-consuming phase of concrete pavement construction. The use of precast elements would eliminate this step while optimizing curing for the precast slabs.

SCOPE OF WORK: Information was searched in order to determine the current state-of-the-art of precasting and the paving industry. Pavement types were evaluated for their potential to be built using precast components. Concepts for the design and construction of precast pavements were identified and evaluated for their feasibility. Finally, recommendations were developed for designs and concepts with the potential for implementation, and also for monitoring the performance of trial installations.

PERIOD OF PERFORMANCE: 1999–2000

COST: $100,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: Center for Transportation Research, University of Texas-Austin/Frank McCullough, in cooperation with Texas DOT

STATUS: Work completed.

UPDATE: The feasibility study has been completed; the results are published as Center for Transportation Research report no. 9-1517-1. The proposed panels are to be cast with continuous shear keys in the edges to aid with alignment when assembled. The panels are pretensioned in the transverse direction during fabrication and post-tensioned in the longitudinal direction during construction. A follow-up project for working with several States to conduct field trials is under way.

TITLE: Use of Precast Concrete Panels to Expedite Highway Pavement Construction—Phase 2: Pilot Studies

TASK/STUDY NUMBER: Task 58-B(98)

OBJECTIVE: Investigate the feasibility and demonstrate the use of precast concrete technology as a means to expedite concrete pavement construction.

BACKGROUND: Precast concrete construction methods have been developed that are viable alternatives for applications such as buildings and bridges. One of the primary benefits of precast components is the speed of construction. Precast elements can be cast under controlled conditions at a precasting yard, far in advance of when they will be needed, then stockpiled and transported to the job site as necessary. Allowing time for concrete to cure before opening to traffic is a time-consuming phase of concrete pavement construction. The use of precast elements would eliminate this step while optimizing curing for the precast slabs.

SCOPE OF WORK: To build off of the successful feasibility study, the use of precast concrete pavements will be investigated through construction of a pilot project to demonstrate manufacturing and construction techniques. Pilot studies will be conducted on temporary roadways or nonservice facilities.

PERIOD OF PERFORMANCE: 2000–2002

COST: $100,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: Center for Transportation Research, University of Texas-Austin/David Merritt

PERFORMANCE MEASURES: Successfully demonstrate the use of the system in the field.

TIMELINE FOR COMPLETION: Pilot project in Texas and California contracted by fall 2002.

STATUS: Pilot project completed on I-35 frontage road in Georgetown, TX, November 2001. Pilot project on I-10 in California was under construction in October 2002.

UPDATE: Final report expected by mid-2003. Papers prepared for Seventh International Conference on Concrete Pavements, Orlando, FL, September 2001; TRB annual meeting, 2002; Precast/Prestressed Concrete Institute conference, October 2003; and TRB annual meeting, 2003.

TITLE: Use of Precast Concrete Panels to Expedite Highway Pavement Construction—Phase 3: Demonstration Projects

TASK/STUDY NUMBER: Task 58-C(98)

OBJECTIVE: Demonstrate the use of precast, post-tensioned concrete pavements as a means to expedite concrete pavement construction.

BACKGROUND: Precast concrete construction methods have been developed that are viable alternatives for applications such as buildings and bridges. One of the primary benefits of precast components is the speed of construction. Precast elements can be cast under controlled conditions at a precasting yard, far in advance of when they will be needed, then stockpiled and transported to the job site as necessary. Allowing time for concrete to cure before opening to traffic is a time-consuming phase of concrete pavement construction. The use of precast elements would eliminate this step while optimizing curing for the precast slabs.

SCOPE OF WORK: To build off of the successful feasibility study and pilot projects by demonstrating precast, post-tensioned pavement construction in the filed applications. This project will provide for engineering support and evaluation of this technology for up to four projects.

PERIOD OF PERFORMANCE: 2003–2004

COST: $250,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: To be determined.

PERFORMANCE MEASURES: Successfully demonstrate the use of the system in the field.

TIMELINE FOR COMPLETION: Demonstration of this technology is anticipated for two projects in 2003 and 2004.

STATUS: Proposals currently are being solicited.

TITLE: Nondestructive and Innovative Testing Workshop

TASK/STUDY NUMBER: Task 59(00)

OBJECTIVE: Introduce Federal, State, and local transportation personnel to currently available nondestructive testing technology that can be used to improve QC/QA testing of new concrete as well as the investigation of defects for existing concrete pavements and bridges.

BACKGROUND: Transferring new technology to highway construction agencies and contractors is often a slow process. FHWA developed and presented several 1-day nondestructive testing workshops to interested SHAs in the mid-1990s. The workshops were well received and a decision was made within FHWA to broaden the scope of these workshops and have a consultant put together a 2-day hands-on workshop.

SCOPE OF WORK: The contractor for this work performed a literature search of existing nondestructive testing equipment for early-age testing of concrete and identifying defects in concrete at later ages. The contractor identified those pieces of equipment that were practical and included them in the hands-on workshop, which will be presented on a national basis to interested SHAs.

START DATE: September 2000

DURATION: Contract extended to March 31, 2003.

COST: $386,000

CONTRACTOR/PRICIPAL INVESTIGATOR: Science Applications International Corporation (SAIC)

PERFORMANCE MEASURES: Workbook and course materials are due March 31, 2003.

TIMELINE FOR COMPLETION: Completion date for workshop materials is March 31, 2003.

STATUS: The Maryland SHA hosted a pilot workshop April 9–11, 2002. More than 35 people attended the workshop. The participants included personnel from the Maryland SHA, FHWA, other government agencies, and industry. Based on the comments received, it was decided to hold a second pilot workshop and include a third instructor. Overall, the comments were very positive and the participants agreed that the workshop should be presented on a national basis. A second pilot workshop was also presented for the Ontario Ministry of Transport by the MCL staff.

The workshop presented information on the following devices: maturity, pull-off (bond test), air-void analyzer, impact-echo, and concrete thickness gauge. For each of these devices, there was either a hands-on session where the participants operated the devices or a demonstration to the group as a whole. A session on new and emerging technologies also discussed such technologies as: FHWA Nondestructive Evaluation Validation Center activities (HERMES II ground-penetrating radar, infrared thermography, and wireless measurement systems), pullout, workability device, cover meter, spectral analysis of surface waves, Roadway Surface Analyzer, dynamic friction tester, and the circular track meter.

The revised cost proposal received by the contractor to incorporate changes from the workshop and deliver 10 workshops was significantly more than the Federal Government estimate and it was mutually agreed upon by both parties that the contractor would finalize the workshop materials and deliver them to FHWA. The funds remaining in the contract would be used to award a new contract for the delivery of the workshops. It is anticipated that the new contract would be awarded by October 2003 and delivery of the workshops would commence in early 2004. Approximately 99 percent of the funds available for the development of the workshop materials and delivery of the pilot workshop have been expended and 95 percent of the work has been completed.

TITLE: Curing of Portland Cement Concrete Pavements

TASK/STUDY NUMBER: FHWA Task 60(99)

OBJECTIVE: Develop guidelines for selecting curing materials and procedures that will ensure adequate curing of pavement concrete, given the variation in concrete mixture proportions and climatic conditions at the time of paving.

BACKGROUND: Proper curing of concrete has a major influence on the performance of that concrete in service. Because of the relatively large surface-area-to-volume ratio for pavements, this statement is particularly true for concrete pavements. "Curing," as used in this project, includes both moisture control and temperature control of the concrete. Guidance is needed for materials and procedures selection in order to ensure proper curing for pavements in a range of situations.

SCOPE OF WORK: Information is to be searched in order to determine the current state-of-knowledge and state-of-the-practice for curing requirements, materials, and procedures for PCCP. The search will include available tests for evaluating the efficiency of various curing materials and procedures in controlling the temperature and moisture of the concrete after placing and finishing. After evaluating the results of the information search, guidelines will be developed for determining the required curing regime in terms of the allowable temperature and moisture ranges of the concrete, and then selecting curing materials and procedures to provide adequate curing based on concrete mixture proportions and the climatic conditions expected during construction. Field tests to monitor and verify the adequacy of the curing shall also be recommended.

PERIOD OF PERFORMANCE: 1999–2003

COST: $395,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: Waterways Experiment Station, U.S. Army Corps of Engineers/Toy Poole, Ph.D.

PERFORMANCE MEASURES: Establish technical advisory panel, collect information, prepare an interim report, complete and evaluate the guidelines, and prepare final version of the guidelines and final report.

TIMELINE FOR COMPLETION: Complete and evaluate guidelines (December 2001), draft final report and guidelines (September 2002), revise final report and guidelines (Dec. 31, 2002), re-revise final report (March 2003), and provide final report (May 2003).

STATUS: Work is somewhat behind schedule, as reflected in the revised completion date noted above. Reorganization and staff reductions at the Waterways Experiment Station have contributed to a slowdown in progress. The first drafts of the deliverables were reviewed and a major shift in the researcher's approach was needed. A second draft of the final report was much better, but still needed additional streamlining and a shift in emphasis. The contractor is now working on the final version of the report to address the latest set of review comments. That report is due by the end of March 2003.

TITLE: Evaluation of Initial PCC Performance-Related Specification Systems

TASK/STUDY NUMBER: FHWA Task 61(99)

OBJECTIVE: Begin the implementation of PRS by having SHAs develop, put into use, and evaluate a PRS system tailored to their needs.

BACKGROUND: Over the past 25 years, there has been a growing interest in the development of PRS for highway pavement construction. The PRS systems are similar to quality assurance specifications; however, the measured acceptance-quality characteristics (e.g., concrete strength, slab thickness, initial smoothness) are directly related to pavement performance through mathematical relationships. Performance is defined by key distress types and is directly related to the future maintenance and rehabilitation costs and the user costs of the highway. This link between acceptance-quality characteristics and future life-cycle costs provides the ability to develop rational and fair contractor pay adjustments that depend on the as-constructed quality delivered for the project. Several FHWA research projects on the development of PRS have now been completed, and guidance for implementing PRS is now available in the form of: (1) a prototype PRS, (2) a 19-step procedure for developing PRS, and (3) software for developing PRS Pavespec software.

SCOPE OF WORK: SHAs that want to implement PRS will follow the information available in FHWA report no. FHWA-RD-98-155, *Guide to Developing Performance-Related Specifications for PCC Pavements*. Each of the agencies will develop PRS as a special provision for use on one or more suitable PCC pavement construction projects. In developing PRS, communications shall be established and maintained with the contractor community and industry associations. Implementation will include the necessary education of potential contractors (through a bid conference), as well as the education/training of State DOT and construction personnel involved in the construction projects.

PERIOD OF PERFORMANCE: 1999–2004

COST: $225,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: Indiana DOT and Florida DOT are the first two agencies that have agreed to participate. Indiana hired Purdue University to help them and Florida hired ERES Consultants, Inc. to help them. At least two more agencies will be sought in FY 2003.

PERFORMANCE MEASURES: Each State develops PRS, uses PRS on one or more projects, and prepares a report on the results.

TIMELINE FOR COMPLETION: Indiana DOT developed and used PRS on a project in 2000. A second project was started in 2002 and will be completed in 2003. Florida DOT has developed PRS that will be used for a project in 2003.

STATUS: Work in progress. Indiana DOT is currently planning to develop and use PRS on a third project.

Percentage of work completed: 80 percent (as of March 1, 2003).
Percentage of funds expended: 80 percent (as of March 1, 2003).

TITLE: Achieving High Levels of Smoothness Without Sacrificing Long-Term Performance

TASK/STUDY NUMBER: FHWA Task 62(01)

OBJECTIVE:
- Assess whether any activities carried out during the paving process in order to achieve some specified level of smoothness could have detrimental effects on concrete properties and pavement performance.
- Provide guidance on adjustments to materials and procedures in order to avoid such potential effects.

BACKGROUND: There has been a continuing trend among highway agencies to specify smoother and smoother pavements. The requirements are steadily being raised in response to the user's increased expectations and the paving contractor's increased proficiency. However, while contractors are finding ways to attain the specified smoothness, it is not clear that the result is always an overall improvement in pavement performance.

Like all materials and construction quality characteristics, smoothness should be considered as having an optimal level. Obviously, it is undesirable to have a newly constructed pavement that is too rough. Alternately, very smooth pavements, if they fail prematurely, are also undesirable. This project will investigate the potential for adverse effects on concrete properties and the performance of concrete pavements resulting from trying to achieve some currently specified levels of smoothness.

SCOPE OF WORK: The contractor will investigate the potential for high-smoothness specifications to have an adverse effect on concrete pavement performance. As part of trying to establish a cause-and-effect relationship, the contractor will collect available information on concrete pavement construction that achieved high levels of initial smoothness, but resulted in a decrease in one or more of the properties of the concrete that are essential to good pavement performance. Selected pavements will be sampled and tested to supplement available information. Data analysis will be conducted to achieve a clearer understanding of the mechanisms involved. Recommendations will then be developed for avoiding adverse effects on concrete properties and pavement performance while conducting paving activities to achieve the specified smoothness.

PERIOD OF PERFORMANCE: July 2001-2004

COST: $388,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: Soils and Materials Engineers, Inc./Starr D. Kohn, Ph.D.

PERFORMANCE MEASURES: Form technical panel, collect information, prepare interim report and work plan, conduct work plan, develop guidelines, and prepare final report.

STATUS: Work in progress. Literature review has been completed. Initial meeting of the technical panel was held. Work plan was modified and approved. Collection and analysis of data are under way. Contractor has fallen behind schedule and it is likely that a time extension will be requested.

Percentage of work completed: 25 percent (as of February 16, 2003).
Percentage of funds spent: 20 percent (as of February 16, 2003).

TITLE: Inertial Profile Data for PCC Pavement Performance Evaluation

TASK/STUDY NUMBER: Task 63(02)

OBJECTIVES:
- Determine if the magnitude of the JPCP slab curvature can be related to pavement performance.
- Determine the extent of the JPCP slab curvature allowable under specific environmental and support conditions to provide long-term performance.
- Identify construction methods or design characteristics to achieve recommendations.

BACKGROUND: It has been known for some time that changes in the shape of PCC slabs because of construction conditions (built-in curvature) and environment (temperature curling and moisture warping) in a jointed pavement system have an influence on pavement performance. Exactly how performance is impacted by slab shape and the magnitude of the changes to the slab shape throughout its life cycle has not been adequately documented. Many previous attempts to quantify the impact of slab shape on performance or determine the shape of PCC slabs on inservice pavements have been limited by an insufficient sample size resulting from the use of manual methods for determining slab shape.

Recent advances in inertial profiling technology developed at FHWA's TFHRC and advances in computer technology make it possible to reliably measure the shape of very large numbers of PCC pavement slabs over a short period of time and perform an analysis of this data. These measurements can be repeated to develop a time-history of pavement slab shape. This technology was recently demonstrated by a high-speed inertial profiler that performed a detailed profile survey of four lanes of a 24-kilometer (km) Interstate pavement four times within a 24-hour period (Sixbey, Dennis; Swanlund, Mark; Gagarine, Nicholas; Mekemson, James R., "Measurement and Analysis of Slab Curvature in Concrete Pavements Using Inertial Profiling Technology", Proceedings of the 7th International Conference on Concrete Pavements, September 2001). Sixbey found that the magnitude of curvature of the slabs surveyed varied from positive 15 mm to negative 15 mm using a best-fit curve and simulated straightedge. The daily change in slab curvature was frequently measured at 5 to 7 mm over a pavement temperature range of 22 °C. It is hypothesized that the slab shape changes in response to construction conditions; diurnal temperature gradients may have a significant role in pavement performance.

With the evolution from empirical pavement design to mechanistic pavement design, determination of changes to the shape of slabs in jointed PCC pavement and the distribution of slab curvature on inservice pavements is critical.

SCOPE OF WORK: Collect inertial profile data using advanced inertial profiling technology for 1610 lane-km (1000 lane-miles [mi]) of jointed PCC pavements, determine slab shape changes over a range of environmental conditions, and relate findings to pavement performance. Guidelines will be developed for maximum slab curvature to achieve extended-life pavements.

Products of this research shall include written guidelines and computer-based guidelines that will focus on the impacts that design and construction decisions will have on slab curvature and ultimate long-term performance. The guidelines will contain recommendations for SHA engineers, including suggested specifications and contractor incentive/disincentive terms for achieving the recommended curvature characteristics.

START DATE: August 14, 2002

DURATION: 30 months

COST: $920,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: The Transtec Group, Inc./Robert Otto Rasmussen, Ph.D.

PERFORMANCE MEASURES: Incorporation of guidelines into PRS, quality assurance for extended-life PCC pavements, and the use of guidelines in the refinement of mechanistically based design models.

TIMELINE: Guidelines will be delivered by June 2005. Validation could be completed by 2006.

STATUS: Data collection to start April 2003.

TITLE: Computer-Based Guidelines for Job-Specific Optimization of Paving Concrete

TASK/STUDY NUMBER: FHWA Task 64(02)

OBJECTIVE: Develop computer-based guidelines for optimizing materials selection and mixture proportioning for job-specific paving concrete.

BACKGROUND: Over the last several years, FHWA, IPRF, NCHRP, and others have conducted a number of studies that dealt with various aspects of the effects of concrete components on the performance of the resulting concrete (using those materials) in concrete pavements. The wealth of information now available is too great to be practically assimilated and combined from existing guidelines, reports, tables, and predictive models in order for a pavement or materials engineer to derive the optimal mix for a given paving project. Therefore, a coordinated effort is needed to take the results of previous work and integrate them into a computer-based system that will guide the concrete materials engineer in selecting the optimal mix for a particular project. Factors that need to be considered include pavement structural design (loading effects), early-age and long-term environmental effects, the construction process, desired service life, available local materials, and cost.

SCOPE OF WORK: The results of recently completed and ongoing studies on materials selection and mixture design for concrete pavements will be reviewed and evaluated in order to develop guidelines for optimizing the resulting concrete for specific projects. Where available information for completing the guidelines is not sufficient, additional information shall be developed. Once draft guidelines have been developed, they will be evaluated in a series of projects, including a range of pavement designs and exposure conditions. The final version of the guidelines will be available in a user-friendly Windows-based computer program.

PERIOD OF PERFORMANCE: 2002–2005

COST: $834,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: The Transtec Group, Inc.

PERFORMANCE MEASURES: Establish advisory panel; collect available information, especially from ongoing and recently completed studies; prepare interim report, including proposed framework for computer software structure and work plan to complete and evaluate the guidelines; develop guidelines and software system according to approved work plan; test software/guidelines in the field; finalize guidelines; and prepare final report.

TIMELINE FOR COMPLETION: August 2006

STATUS: Work in progress, 5 percent completed.

UPDATE: Contract was awarded on August 30, 2002. A technical panel, consisting of several State DOT concrete engineers, contractors, and various trade associations, was formed. The first meeting took place in November 2002. At that meeting, the panel provided direction and feedback to the contractor on their proposed approach. Since then, the contractor has been collecting information (literature review) and evaluating approaches for designing the final computer-based product. An interim report discussing the technical scope, information gaps, options for software development, a framework for the guidelines, and a detailed work plan for the remainder of the project was submitted in June 2003. A second panel meeting was held at the end of June to present this report to the panel.

TITLE: Technology Transfer, Deployment, and Delivery for the Concrete Pavement Technology Program

TASK/STUDY NUMBER: FHWA Task 65(03)

BACKGROUND: This contract will provide the engineering and communications services needed for the technology transfer, deployment, and delivery of products resulting from CPTP. CPTP comprises R&D projects that have been identified by FHWA's partners and customers in the States, industry, and academia. CPTP supports the goal of the FHWA Infrastructure Office of Pavement Technology to advance long-life practices that improve pavement durability, smoothness, and cost effectiveness throughout the National Highway System. CPTP also supports FHWA's national goals of reducing user delays and costs, improving performance, and fostering innovation.

SCOPE OF WORK: The scope of the work to be performed under this contract will be defined both by the products that result from CPTP and by the communications and outreach strategy that is proposed through an offer and accepted by the Federal Government. The technology-transfer program is for the benefit of FHWA's customers and partners, and it will be planned and executed in a timely and cost-effective manner. The program will clearly demonstrate the value of the products resulting from CPTP and will deliver benefits to a variety of end-user groups in the highway community, including the States, industry, and academia.

PERIOD OF PERFORMANCE: The planned period of performance is a minimum of 1 year, up to a maximum of 5 years, subject to the availability of funding.

COST: Procurement request number 50-53-3065 (approved December 20, 2002), with total estimated cost of $5.0 million, is allocated as follows:
- Base year 2003, $2.0 million
- Option year 2004, $900,000
- Option year 2005, $900,000
- Option year 2006, $900,000
- Option year 2007, $300,000

CONTRACTOR/PRINCIPAL INVESTIGATOR: Contracting documents prepared through March 2003 for posting on the FedBizOpps (http://www.fedbizopps.gov/) Web site on the World Wide Web are as follows:
- Sources sought.
- Requests for proposals.

PERFORMANCE MEASURES: Successful performance requirements are as follows:
- Preparation of a detailed status report for the CPTP projects and products.
- Development of a marketing plan.
- Implementation of technology transfer, deployment, and delivery activities in a timely and cost-effective manner.

TIMELINE FOR COMPLETION: To be determined.

STATUS: Estimated solicitation release date is first quarter FY 2003.

UPDATE: Pre-award activities completed as shown above.